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# Experimental study of stabilizationof soil using nano silica.

# Estudio experimental de estabilización de suelos mediante nano sílice.

R. Vinodh Kumar [1], Ahfaz Husain Khan[2]

Department of Civil Engineering, Meenakshi College of Engineering, Chennai, India

Email(1): er.r.rvinodhkumar@gmail.com, Email(2): ahfazkhan219@gmail.com

ABSTRACT

The behavior of structures depends on the properties of the soil on which they are constructed. Some problems like settlement and bearing capacity are critical for structures over the expansive soil; the soil sample has been characterized as expansive soil based on swelling test. Stabilization techniques are adopted to enhance the expansive soil behavior and performance of foundation overlying weak soil. This paper focuses on studying the effect of nanomaterials (Nano MgO and Nano Al2O3) with differentproportions, 0.5%, 1.0%, 1.5% and 2.0% on the properties of expansive soil. The results indicate that swelling potential is reduced with the addition of these nanomaterials and thus making the soil suitable forconstruction purposes.

Keywords- Expansive soil, Nano particles, Soil Stabilization.

RESUMEN

El comportamiento de las estructuras depende de las propiedades del suelo sobre el que están construidas. Algunos problemas como el asentamiento y la capacidad de carga son críticos para las estructuras sobre suelo expansivo; la muestra de suelo se ha caracterizado como suelo expansivo basándose en la prueba de hinchamiento. Se adoptan técnicas de estabilización para mejorar el comportamiento expansivo del suelo y el rendimiento de los cimientos que se encuentran sobre suelos débiles. Este trabajo se centra en estudiar el efecto de los nanomateriales (Nano MgO y Nano Al2O3) con diferentes proporciones, 0,5%, 1,0%, 1,5% y 2,0% sobre las propiedades del suelo expansivo. Los resultados indican que el potencial de hinchazón se reduce con la adición de estos nanomateriales, lo que hace que el suelo sea adecuado para fines de construcción.

Palabras clave- Suelo expansivo, Nanopartículas, Estabilización de suelos.

## INTRODUCTION

As one of the characteristics of clay soil to expand, swell and shrink in many weather conditions and circumstances it might lead to an inevitable catastrophe or hazard to the building, properties and to the people who live in it. Expansive soil has high moisture, low shear strength, low bearing capacity and high settlement. These soils are enriched with mineral that are capable of absorbing water and as a result of absorbing water their volume expands. The building constructed on such soil may fail due to this variation in volume. Thus, structures on expansive soil are always associated with the problems of settlement and stability. This case could even occur for the other different types of soils added with the condition and environment of it. In order to build any type of structure by considering the needs and interest of the client we need to stabilize the soil for reduction of any risk that could possibly occur in the near future. In this

research we have studied behaviours of clay soil sample by conducting various experimental tests.

## MATERIALS AND METHODS

- Clay soil (from Mellakal)
- Nano silica (chemical admixture)

Fig 1 - Clay Soil and Nano Silica

Table – 1 Physical and Chemical Properties of Nano Silica

| Description | Result | Description | Result |
|---|---|---|---|
| Chemical Properties | | Physical Properties | |
| Appearance form | Powder | Density | 2.17 – 2.66 gr/cm$^3$ |
| Particle Size | 15 nm | Melting point | ±1700ºC |
| Color | Colorless (White) | Boiling point | 2230ºC |
| Density (25ºC) | 2.2 – 2.6 g/mL | Color | White |
| Molecule | $SIO_2$ | Particle size | 10 – 20 Nanometer |
| | | Bulk density | 0.011 gr/ml |

Mixture of Nano Silica and Soil: From the collected soil sample 50 % of the soil samples are separated and 10%of the nano silica powders have mixed manually. The mixed soil has been kept in a air tight container to maintain themoister content of the soil.

In this research we have conducted the following tests for both the original clay soil and soil mixed with nano silica to determine the characteristics of soil like Atterberg's limit optimum moisture content, dry density, shear strength and unconfined compression for different concentration of nano silica with silty sand clay soil. Those are,

1. Liquid Limit Test
2. Unconfined compression test
3. Standard proctor compaction test
4. Direct shear test
5. Swell index

Fig 2 – Test on original clay soil and soil mixed with nano silica

## RESULTS AND DISCUSSION

Liquid Limit Test Result:

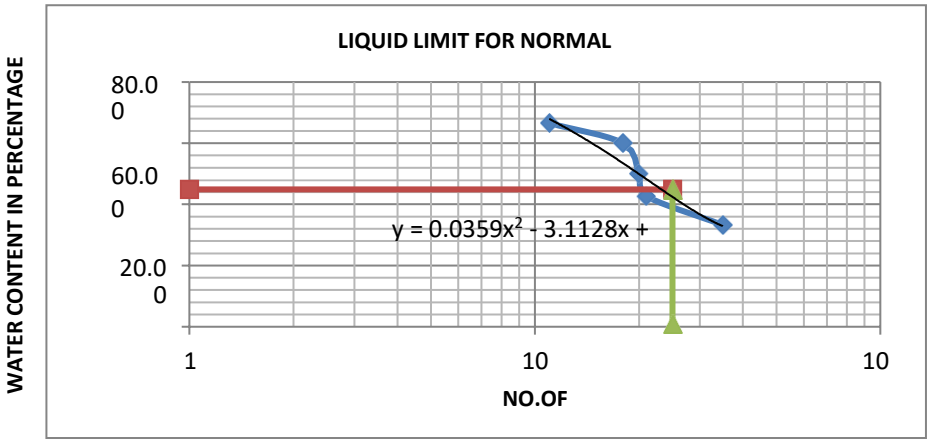



Fig1: Liquid limit curve of soil sample

Liquid limit is 44.92 from graph.

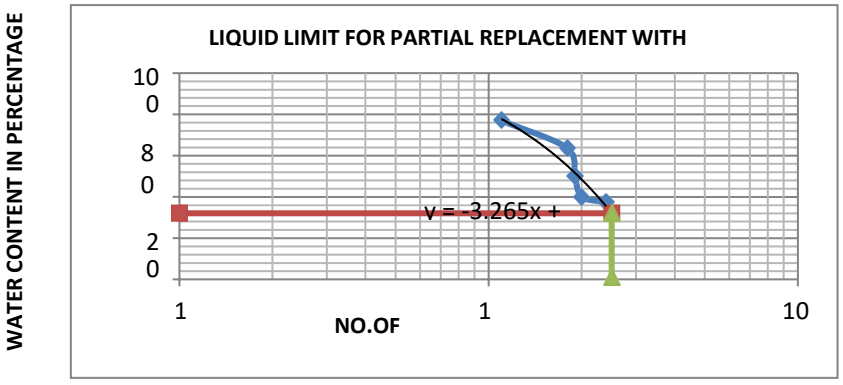



Fig 2: Liquid limit curve of - Partial replacement with Nano Silica

Liquid limit is 32.07 from graph.

Unconfined Compressive Strength Test :

The unconfined compressive strength (Qu): Qu = P/A

$$A = \text{corrected area} = \frac{A_0}{1-s}$$

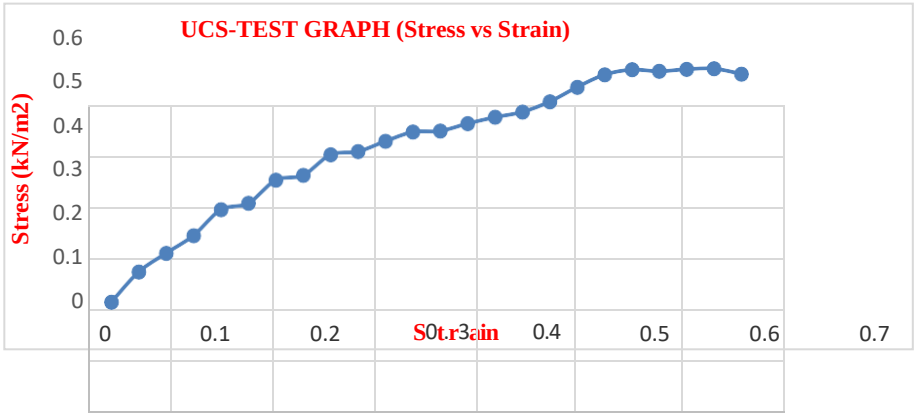



Fig3: Unconfined Compressive Strength Test for Normal Sample

Qu = 0.743 kg/cm$^2$

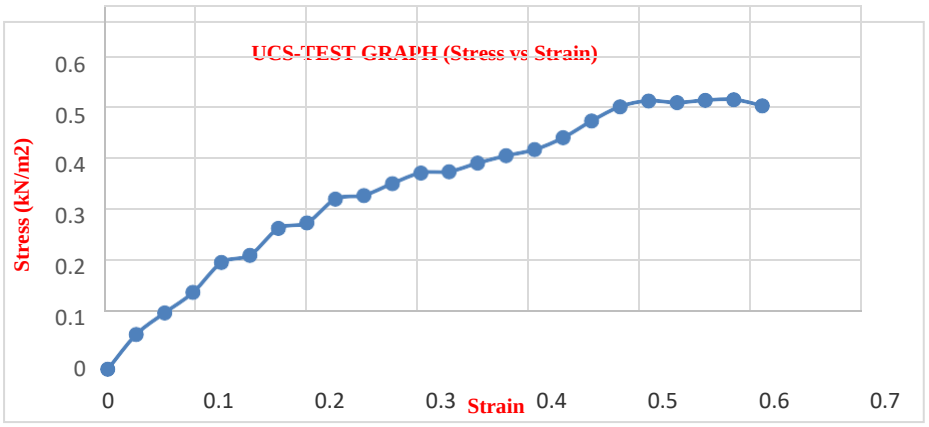



Fig 4: Unconfined Compressive Strength Test for Partial Replacement Nanosilica Sample

Qu = 1.286 kg/cm$^2$

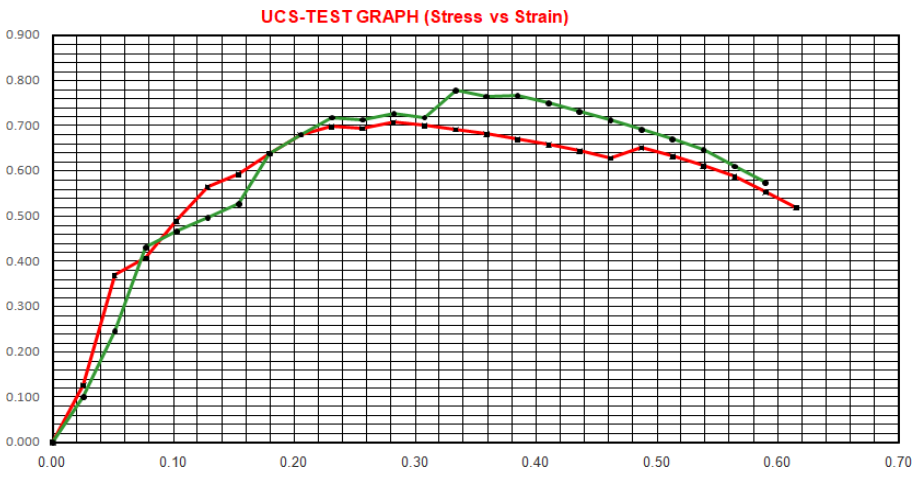



Fig 5: UCS Curve of Partial Replacement of Soil Sample

The Maximum Unconfined Compression strength of soil sample= 7.626 MPa

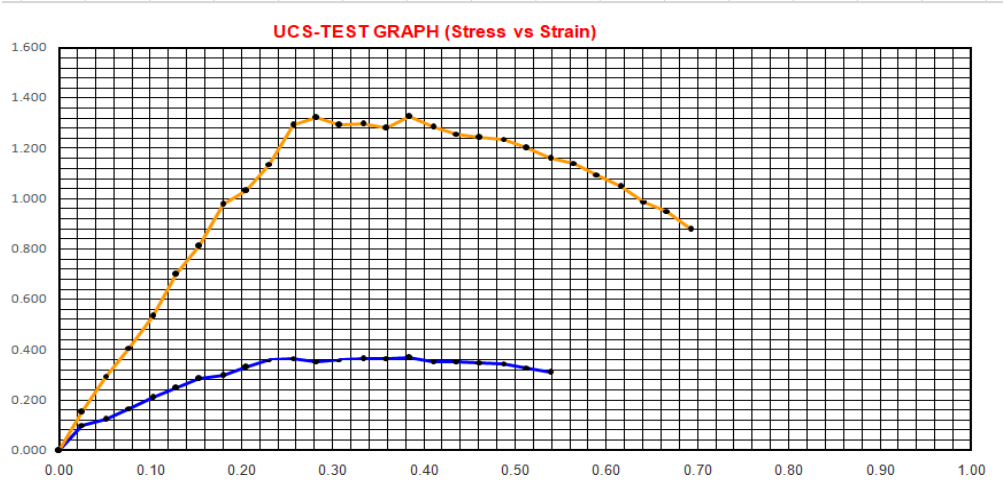



Fig 6: UCS Curve of Partial replacement of Nano Silica

The Maximum Unconfined Compression Strength of soil sample with partial replacement of Nano silica= 13.0 MPa

Standard Proctors Compaction Test Result:

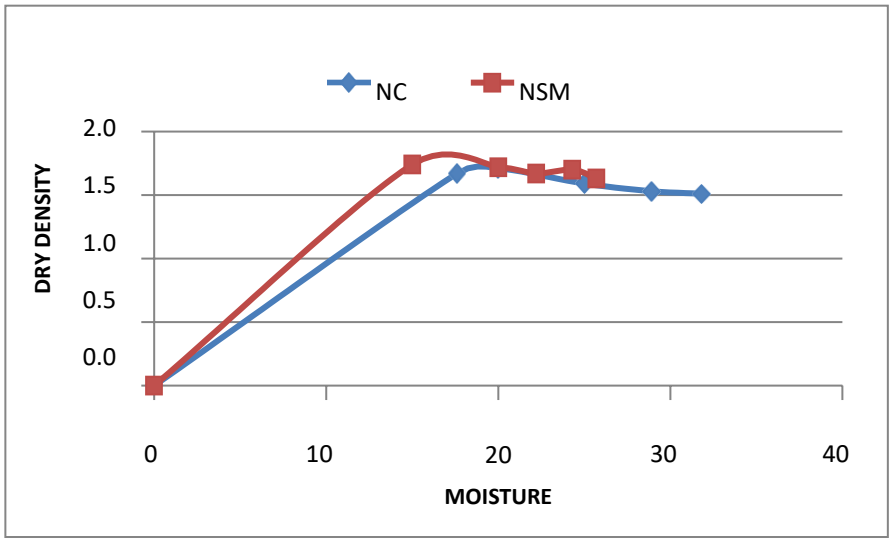



Fig 7: Compaction curve of normal & Nano Silica mixed sample

Table – 3 Moisture content and Density

| Sample | Moisture Content (%) | Density (g/cc) |
|---|---|---|
| Normal Soil Sample | 17.0 | 1.71 |
| Silica mixed Soil Sample | 15.0 | 1.76 |

Direct Shear Test Result:

$rf = c + \alpha \tan\theta$

$\alpha = Normal\ stress = \dfrac{Normal\ force\ (p)}{Cross\text{-}Sectional\ Area\ of\ sample}$

Table – 4 Direct Shear Test of Soil Sample

| Weights (kg) | Shear Stress ($kg/mm^2$) |
|---|---|
| 0.5 kg | 0.38 |
| 1.0 kg | 0.45 |
| 1.5 kg | 0.46 |

Table – 5 Direct Shear Test of Soil Sample with Partial Replacement of Nano Silica

| Weights (kg) | Shear Stress ($kg/mm^2$) |
|---|---|
| 0.5 kg | 0.67 |
| 1.0 kg | 0.86 |
| 1.5 kg | 1.02 |

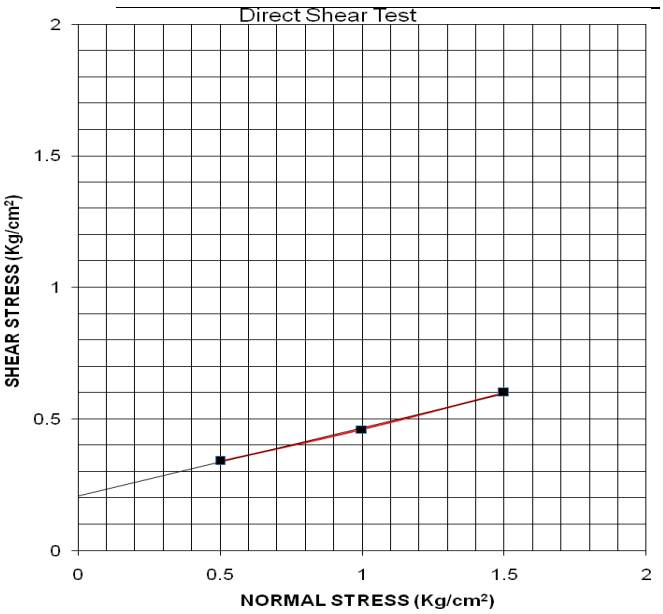
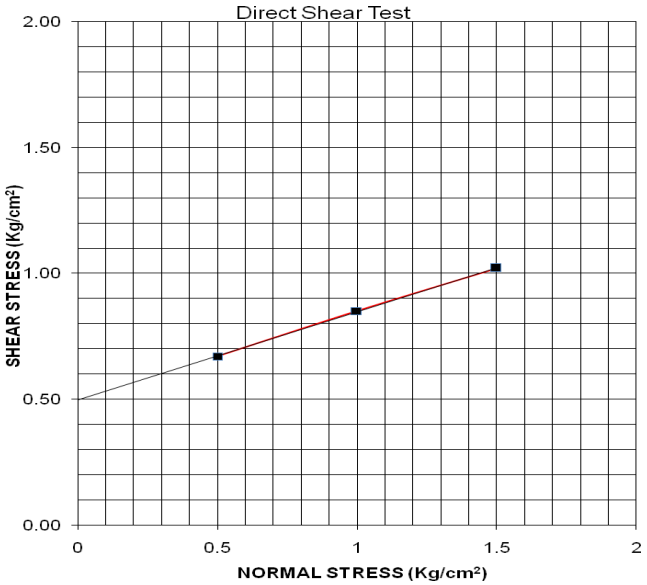



Fig 8: Direct Shear Curve of Normal Soil Sample




From the above figure the cohesion of the soil found to be 0.2

Fig 11: Direct Shear Curve of Normal Soil Sample with Partial Replacement of Nano silicaFrom the above figure the cohesion of the soil found to be 0.5

Free Swell Index Test Result

NORMAL SOIL SAMPLE:

For Normal water 25ml of soil swelled up to 27ml &amp, for kerosene 23ml of soil swelled up to 24ml.

Free swell index= [(26-22)/22] ×100= 18.1%NORMAL SOIL

SAMPLE MIXED WITH NANO SILICA

For Normal water swelled from 20 to 26ml & for kerosene Swelled from 20 to 22 ml.

Free swell index [(27-24)/24] ×100 = 12.5%

## CONCLUSION

The liquid limit of the normal soil was found to be 44.92 whereas partially replaced nano silica soil to be 32.07. The percentage in the reduction of liquid limit was 28.60. The optimum moisture content based on the standard proctor compaction test for the normal soil was found to be 1.71g/ccwhereas partially replaced nano silica soil to be 1.76g/cc. the percentage in the reduction of optimum moisture content was 2%

The cohesion between the particles based on direct shear test for the normal soil has found to be 0.2 whereas partially replaced nano silica soil as 0.5. The percentage in the reduction of cohesion was 150% because it is 1.5 times more than ordinary one. The shear strength of the soil based on the unconfined compression test has found to be 7.626N/mm$^2$ whereas partially replaced nano silica soil as 13 N/mm$^2$. The percentage in the reduction shear strength was 70.46%. The swelling of the normal soil has found to be 18.1% whereas partially replaced nano silica soil to be 12.5. The percentage in reduction of shear strength was 44.8%. From the above points we conclude that replaced nano soil is more stable than the normal soil.

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